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# Shock Wave and EUV Transient During a Flare

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**Abstract.** A metric type II burst and a 'brow' type enhancement in EUV were observed during the hard X-ray flare of 1997 April 15 from a newly emerging region, AR 8032. The position of the type II burst obtained from the Nancay radioheliograph coincided with the EUV transient. The type II burst and the EUV transient were in the equatorial streamer region to the north of the flaring region. This observation suggests that the EUV transient may be the manifestation of the MHD shock responsible for the type II burst.

## 1. Introduction

Origin of coronal shocks responsible for metric type II bursts is not well understood. Coronal mass ejections (CMEs), flare blast waves, and high temperature ejecta have been proposed as possible candidates to drive the shock. The EUV transients (Thompson et al., 1999) discovered by the Solar and Heliospheric Observatory (SOHO) mission's Extreme-ultraviolet Imaging Telescope (EIT) is another phenomenon (also known as EIT Waves) closely related to the type II bursts (Klassen et al., 1999). Even though there is good temporal association between EIT waves and type II bursts, the physical relation between them is poorly understood mainly due to lack of simultaneous observation (Maia et al., 1997; Pick et al., 1997). During a small flare on April 15, 1997 a type II burst was imaged by the Nancay Radioheliograph. There was simultaneous observation by SOHO/EIT, so we have an opportunity to compare the radio and EUV activities. In this paper, we report on this comparison.

## 2. Observations and Analysis

The flare occurred in AR 8032 which emerged only the previous day and grew rapidly in area and complexity. Fig. 1 shows an evolution of the emerging region from 11:18 UT on April 14, 1997 to 11:18 UT the next day. The flare occurred on the western part of this region where the flux emergence was most rapid. The hard X-ray emission was very brief with several spikes during 14:10 to 14:14 while the GOES soft X-ray emission started as early as 14:00 UT and ended at 14:26 UT. A metric type II burst started around 14:15 UT and lasted until about

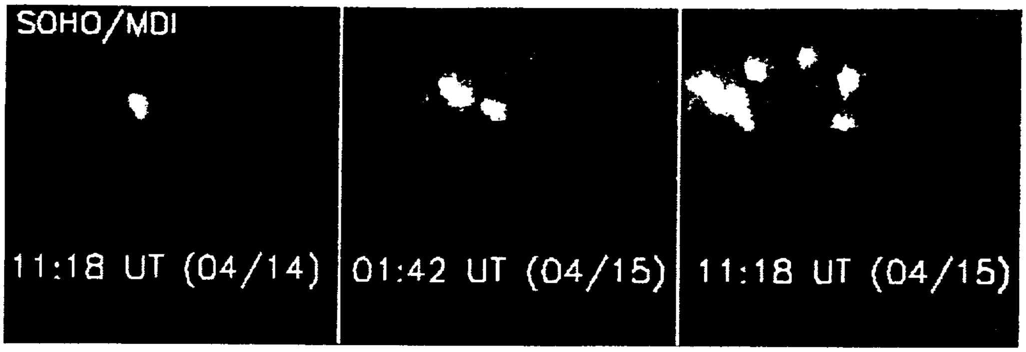


Figure 1. SOHO/MDI magnetograms showing the rapid emergence of AR 8032. White and dark are positive and negative magnetic polarity respectively. The flare occurred at the westernmost part.

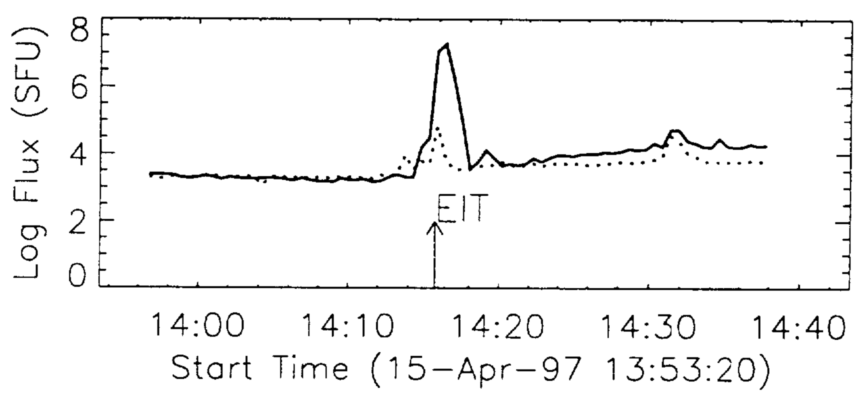


Figure 2. Time variation of radio flux at 164 (solid) and 236 (dotted) MHz. The type II is the large increase around 14:16 UT. The time of EIT image is marked.

14:30 UT with fundamental and harmonic components. The highest frequency of (harmonic) emission was 250 MHz. The Nancay radioheliograph was observing at four frequencies during the flare, but the type II burst was observed only at the two lowest frequencies (164 and 236 MHz) as harmonic emission. Fig. 2 shows the type II burst at 164 and 236 MHz as a brief enhancement. The type II burst continued down to $\sim$ 25 MHz, but was not seen in the Wind/WAVES spectral domain starting at 14 MHz.

The SOHO/EIT obtained full disk images every 19 minutes in the Fe XII line (195 Å ). The 14:15:46 UT image happened to be within the flare period and coincided with the onset of the type II burst (see Fig. 2). The 14:15:46 UT EIT image in Fig. 3 shows a compact brightening in the active region and a large-scale enhancement primarily to the north of the active region. The enhancement was in the form of a 'brow' above the active region (the 'eye'). We have also

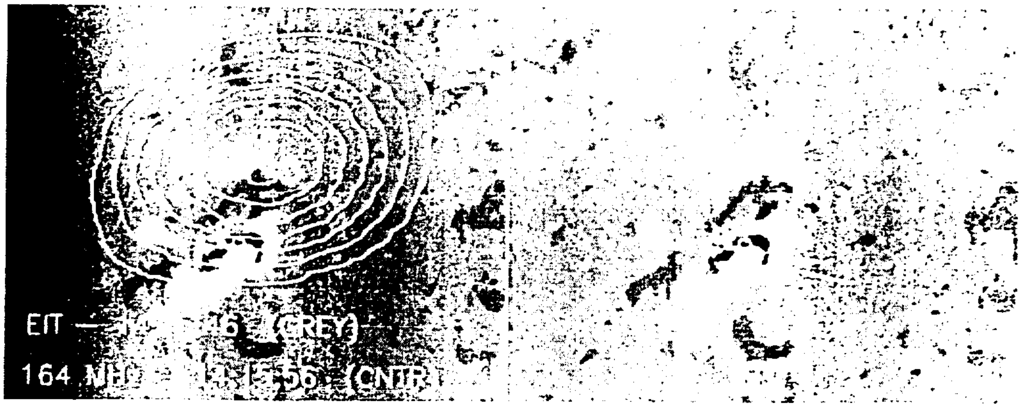

Figure 3. Superposition of 164 MHz type II burst contours on an EIT difference image obtained by subtracting the 13:41 UT image from the 14:15:46 UT image. The EIT brow can be clearly seen to the north of AR 8032. North is to the top and east to the left.

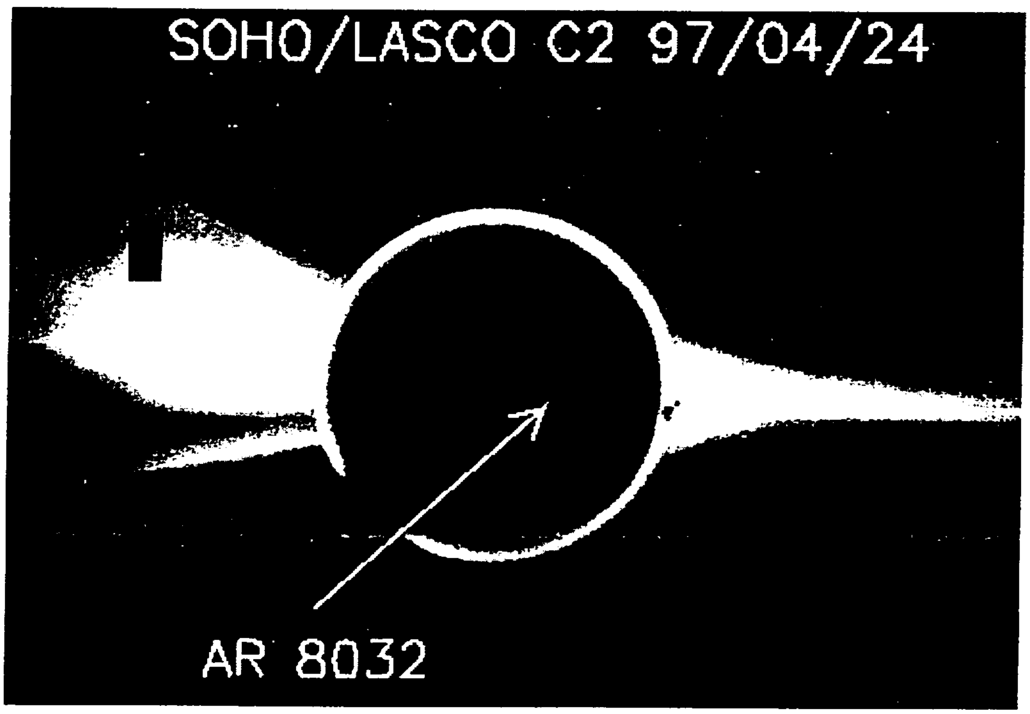


Figure 4. A SOHO/LASCO C2 image of the corona on April 24, 1997. The location of AR was roughly on the limb at the southern edge of the streamer base. The type II burst was probably located within the body of this streamer.

shown the contour image of the type II burst superposed on the EIT brow in Fig. 3 (left). The type II burst was observed nearly at the same time as the EIT image. The results of this analysis can be summarized as follows: (i) the centroid of the type II burst is coincident with the brightest portion of the EIT brow, (ii) the eastwest extent of the EIT brow is roughly same as that of the type II source, (iii) the EIT brow and the type II burst are both located to the north of the active region, even though AR 8032 was in the southeast quadrant of the solar disk. In order to understand the coronal configuration near the eruption, we examined the SOHO/LASCO white light images obtained several days after the eruption. Figure 4 shows a narrow streamer structure above the west limb on April 24, 1997 - nine days after the flare. AR 8032 rotated to the west limb around this day (pointed by arrow). It is clear that AR 8032 was located at the southern edge of the streamer. From this we can infer that the type II burst and the EIT brow wave were located within this streamer.

## 3. Discussion and Conclusions

It is significant that the type II burst and the EIT brow were located to the north of AR 8032. One would normally expect them to be located radially above the flaring region. This implies that the propagating disturbance formed the shock only inside the streamer. It was shown long ago by Uchida (1974) that mHD shocks strengthen inside such streamers. Gopalswamy et al (1997) found similar evidence for type II location using X-ray and white light observations during another event. There was no other CME reported by SOHO/LASCO. Roughly an hour before the flare in question, there was a filament disappearance to the south of the active region resulting in a long-lived arcade formation in EUV. This definitely indicates a CME, but the CME clearly precedes the type II burst by more than an hour. We therefore infer that the EIT wave originated from the flare at 14:10 UT. If we take that the EIT wave left the flare site during the impulsive phase (14:12 UT), then the EIT wave must have traveled with a speed of about 1000 km $s^{-1}$, consistent with the typical speed of metric type II bursts. In conclusion, we were able show that the metric type II burst was spatially coincident with the EIT wave (brow type). One may infer that the EIT wave, especially the brow type is a manifestation of the MHD shock wave responsible for the type II burst. The flare associated disturbance seems to have become shock wave only in the streamer region to the north of the active region.

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